A FEW SUGGESTIONS RELATING TO THE SELECTION OF ELECTRICAL MEASURING INSTRUMENTS

FOR USE IN THE LABORATORIES OF HIGH SCHOOLS
AND COLLEGIATE PREPARATORY SCHOOLS

MONOGRAPH B-1

SECOND EDITION, AUGUST, 1914

ISSUED FOR
SCIENCE TEACHERS IN EDUCATIONAL INSTITUTIONS

> "If one were called upon to name a single word which, more than any other, is the keyword to modern science, one would be tempted to say that 'quantitative' is that word. Measuring, weighing, counting—these and the perfection of the processes concerned with them have been the foundation of that magnificent advance of the sciences which is the most distinguishing characteristic of the modern world."

WESTON ELECTRICAL INSTRUMENT CO.
NEWARK, N. J.

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PREAMBLE

MONOGRAPHS B1, B2 and B3, now combined under one cover, were originally issued separately.

The object of this Company in preparing and distributing these and subsequent monographs, is to endeavor to prove of material assistance to the Science Teachers of this country in matters pertaining to electrical experiments and electrical apparatus in the laboratories of High Schools and Collegiate Preparatory Schools.

Monograph B1 was first issued in an edition of 10,000 in 1913.

Monograph B2 and B3 combined was also originally issued in an edition of 10,000, and a revised edition of B2, entitled "Monograph 2, Joint Committee Series," was later formally adopted by the National Education Association, and under its auspices a special edition of 10,000 was prepared and distributed with the 1913 report of its proceedings.

The increasing demand for copies of these Monographs has necessitated the preparation of this edition, and for the convenience of Science Teachers we have combined the three publications under one cover.

In this combined second edition we have revised the text to some extent, improved the illustrations and added a few new models of instruments to those originally recommended in Monograph B3.

In all other essential details it conforms to the prior editions, and, as has previously been the case, it is distributed gratuitously.

We desire to express our appreciation of the interest manifested in these publications by Science Teachers and also wish to state that Monograph B4 is available upon request.

New Monographs will be prepared as rapidly as interesting and pertinent matter can be accumulated.

To promote this end, we once more urge instructors to

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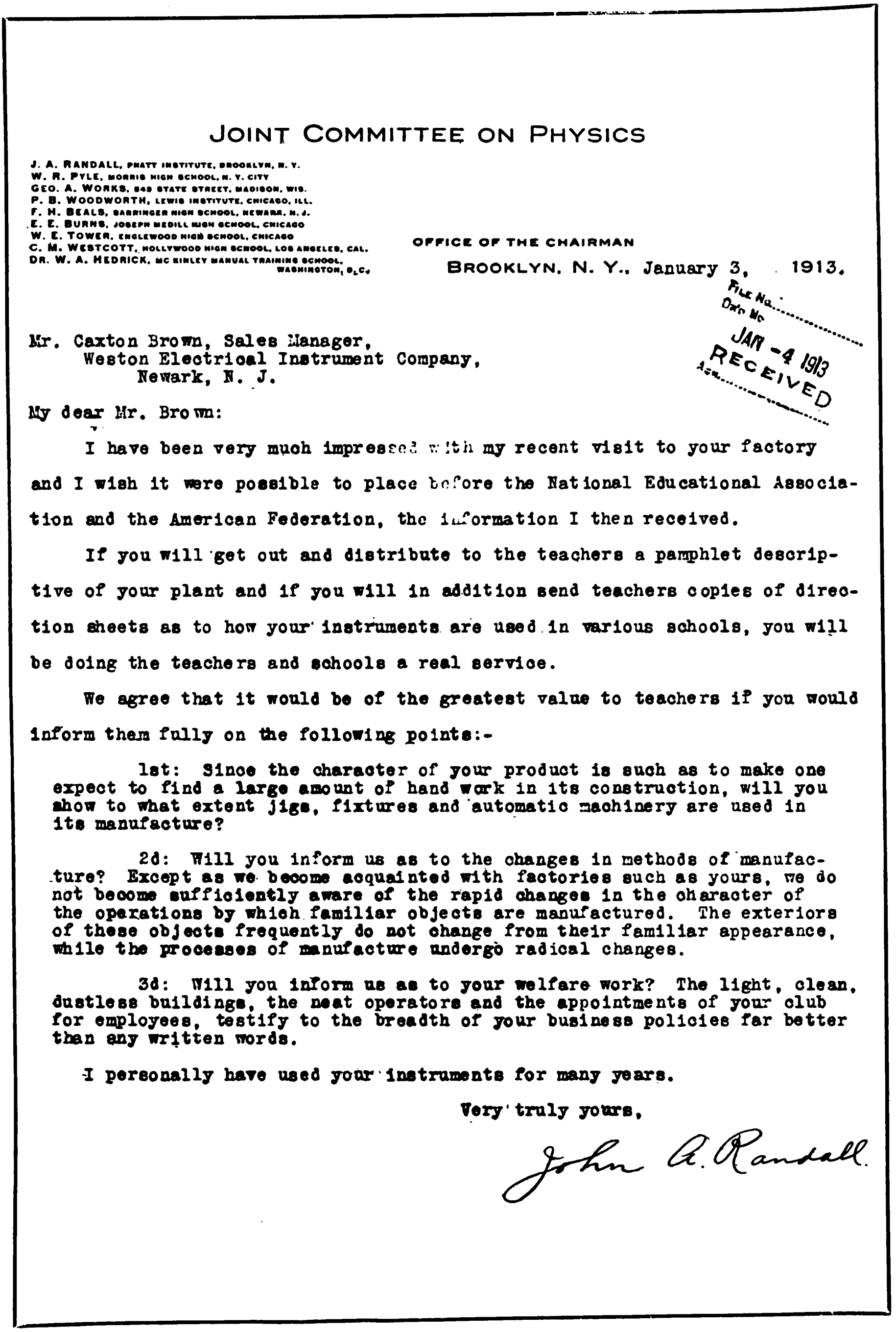
cooperate with us by contributing exercises in electrical measurements performed by students.

It may be of interest to Science Teachers to note that there is still available for distribution a limited supply of a set consisting of two large laboratory wall charts illustrating the principle of operation and method of construction of Weston Direct Current Switchboard Instruments.

WESTON ELECTRICAL INSTRUMENT COMPANY.



JOINT COMMITTEE ON PHYSICS

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GEO. A. WORKS, 543 STATE STREET, MADISON, WIS.
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OFFICE OF THE CHAIRMAN

BROOKLYN, N. Y., January 3, 1913.

File No.
Ord. No.
JAN -4 1913
RECEIVED
Ans.

Mr. Caxton Brown, Sales Manager,
Weston Electrical Instrument Company,
Newark, N. J.

My dear Mr. Brown:

I have been very much impressed with my recent visit to your factory and I wish it were possible to place before the National Educational Association and the American Federation, the information I then received.

If you will get out and distribute to the teachers a pamphlet descriptive of your plant and if you will in addition send teachers copies of direction sheets as to how your instruments are used in various schools, you will be doing the teachers and schools a real service.

We agree that it would be of the greatest value to teachers if you would inform them fully on the following points:-

1st: Since the character of your product is such as to make one expect to find a large amount of hand work in its construction, will you show to what extent jigs, fixtures and automatic machinery are used in its manufacture?

2d: Will you inform us as to the changes in methods of manufacture? Except as we become acquainted with factories such as yours, we do not become sufficiently aware of the rapid changes in the character of the operations by which familiar objects are manufactured. The exteriors of these objects frequently do not change from their familiar appearance, while the processes of manufacture undergo radical changes.

3d: Will you inform us as to your welfare work? The light, clean, dustless buildings, the neat operators and the appointments of your club for employees, testify to the breadth of your business policies far better than any written words.

I personally have used your instruments for many years.

Very truly yours,

John A. Randall

ELECTRICAL MEASURING INSTRUMENTS

There is printed on page 5 a copy of a letter received from Mr. John A. Randall of the Pratt Institute of Brooklyn.

Mr. Randall is chairman of the committee appointed to hasten the evolution of physics teaching. The special problem in which he is at present interested is that of the equipment of the laboratories of the High Schools. In the course of his investigation of what commercial electrical measuring instruments are best adapted to school use, he visited our factory.

We were very much pleased to receive subsequently the letter to which we have directed attention, because it suggested that we might be of service to the science teachers in High Schools if we made it easy for those who were sufficiently interested to obtain reliable and thorough information concerning the essential characteristics and methods of construction of the highest grade electrical measuring instruments.

The idea of preparing such information was not entirely novel, inasmuch as our sales representatives had often written to us of visits made to teachers in High Schools in their localities, and had frequently quoted their opinions, but we had hesitated to attempt to send out any publications until the receipt of of Mr. Randall's letter, which indicated the form in which the teacher would most appreciate receiving the information.

We shall therefore endeavor to comply with his request, but in order to be of the greatest service to science teachers we consider it advisable to separate our subjects and treat them in a series of monographs.

The Scope of this Monograph. This monograph is merely intended to set forth a few general remarks relating briefly to the new progressive movement among science teachers and for the purpose of submitting a few arguments in behalf of the selection of high-grade electrical measuring instruments as a part of the laboratory equipment.

It has also been prepared for the purpose of ascertaining whether the majority of teachers will actually welcome subsequent information that will enable them to acquire a more or less complete comprehension of the problems encountered in the production of really serviceable instruments, the best methods of adapting them to their requirements, and a means of ascertaining whether it will be of distinct advantage to themselves and their pupils to use the best instruments that are procurable, instead of the types of instruments that have heretofore been most generally used in the High School laboratories.

THE OPINION OF AN AUTHORITY

Recently one of the highest authorities on educational matters expressed himself to our sales manager in substantially the following words:

" The value of a course in physics in the High School depends greatly upon the manner in which a teacher has prepared himself to instruct the students.

" But no matter how conscientiously the teacher has prepared himself, he is fearfully handicapped unless his laboratory equipment includes the proper apparatus to allow him to perform his experiments in an interesting and, therefore, a forceful and appealing manner.

" It is true that our laboratory equipment has in the vast majority of schools been extremely poor, and it is not exaggeration to state that inadequate experiments have been conducted with crude apparatus for several decades.

" No greater misfortune could have transpired; but fortunately an era of awakening has recently dawned, and the progressive teachers are leaving the rut in which we have all been moving, and will no longer neglect educational progress in elementary physics or other lines of practical utility.

" Our industrial betterment has been chiefly dependent upon the ever-increasing practical application of science to the commercial arts, and the mistake that most of us have made is to have failed to appreciate the significance of that fact.

" Moreover, many of us have labored under the delusion that the underlying laws and principles relating to scientific matters are profound and perplexing, while the truth of the matter is that they are extremely simple to understand providing they are explained in a lucid, interesting, and impressive manner.

Development of Common-sense. "Elementary science courses should be so planned as to stimulate and develop sound common-sense and judgment relating to the matters dealt with. Youth is so impressionable and receptive that actual practical experience in making experiments with real instead of pseudo-real apparatus is of inestimable advantage.

Practice and Theory. "While the pupil is acquiring his practical knowledge, through using his own mind and hands, he will be forced to ask questions, and then is the time that the theory of the experiment should be expounded. That is, practice should be of equal, if not of greater, importance at this stage than theory, though of course the two should never be separated.

"It is fortunately becoming generally accepted that practical work is of vital importance, and the best authorities are continually emphasizing the necessity of encouraging, yes, insisting, that the students shall perform their experiments with real apparatus identical with the types they will use later in practical commercial work. Consequently, they are using every effort to discourage the use of the makeshift apparatus that several dealers and manufacturers have prepared and advocated for many years past."

In that excellent book, "The Teaching of Physics," by Prof. C. R. Mann, and in almost every number of "School Science and Mathematics," teachers will find the ideas we have quoted crystallized and expounded. In fact, it is now difficult to pick up any periodical or attend any lecture or conference dealing with educational matters without finding the same thoughts reiterated, and the intense concentration on the subject is rapidly accomplishing the end that is sought.

HISTORICAL

It is of interest to refer briefly to the influence of accurate electrical measuring instruments upon the development of the electrical industry in general.

What Accurate Instruments Mean to the Electrical Engineer. Before dependable electrical instruments became available, the electrical engineer was in substantially the same position as the civil engineer would be to-day were he called upon to design and construct a steel railway bridge without the assistance of reliable standards of length, weight, tensile strength and resistance of the material he intended to use; or as the astronomer of to-day without his high-powered lenses, or the bacteriologist without his microscope, or the mariner without his sextant.

Prior to 1888 the types of electrical measuring instruments at the disposal of scientific workers, or those engaged in the practical applications of electricity to commercial and industrial purposes, were far from satisfactory.

In fact if we except the tangent galvanometer, which was reliable for accurate results only when used with the greatest care, and was not at all adapted to ordinary commercial work, there were no switchboard or portable instruments that met practical requirements.

Those who were engaged in electroplating, electrotyping, electrometallurgy, electric lighting, electric transmission of power, electric telegraphy, etc., keenly felt the need of instruments better adapted to the measurement of current strength and electromotive force than any instrument then known. So pressing was this demand in the exacting requirements of practical and scientific work that a myriad of processes, pieces of apparatus and applications of electricity that have now been brought to so high a state of efficiency, were practically held in suspense, because there were no adequate means of precisely measuring the electrical forces dealt with.

Speaking as a class of such instruments as were then in vogue, it may be said that they were in reality nothing better than mere indicators of the values they were intended to measure, and substantially all of them were crudely designed and constructed.

But the advent of the Weston permanent-magnet moving-coil type of instrument in 1888 changed all this.

Although a number of distinguished scientists in several countries were endeavoring to solve the problem of producing a type of instrument that would be accurate, direct reading, and convenient to use under all the conditions of practical work, Edward Weston was the only one to attain this end.

He was the first to employ a practically closed magnetic field, and a uniform field in an electrical measuring instrument, and to produce an instrument that had a long uniform scale and was direct reading, accurate, and convenient to use. He also secured excellent control of the moving system, so that the pointer almost immediately came to rest at the true indication when large or small changes in current strength or electromotive force occurred, irrespective of whether the fluctuations of the circuits were rapid or slow.

Broad basic patents were granted to him for these inventions, and simple as his new type of instrument seemed to be after the problem was solved, the development of it was a feat of tremendous import to all users of electricity.

Then, for the first time, commercial instruments of a type and form that met all the urgently needed requirements were available, and it is no exaggeration to state that the unparalleled impetus given to matters pertaining to the development of the electrical industry was due chiefly to the new means of measurement and the precise determinations it made possible.

Why Handicap Students? Bearing this sketch of the importance of the revolution of the art of electrical measurement in mind, does it not seem a step in the wrong direction to handicap students by not giving them reliable and dependable instruments?

Is it not indeed somewhat similar to training an army of recruits with medieval crossbows and expecting them to do the duty of an army of regulars equipped with modern repeating rifles, or to training a class of students in an agricultural college to plow with a pointed stick when the implement which will later be placed in their hands is a modern plow?

There is no sound reason why pupils should not, and every reason why they should, be trained with the same apparatus they will use in practical work after leaving the school.

EXTENT OF THE USE OF WESTON INSTRUMENTS

As this monograph is prepared for the purpose of interesting and serving those teachers of science whose location prevents us from sending a representative from one of our district offices, it is not amiss to state that already Weston instruments (the world's standards) are widely used in High School laboratories of our larger centers, and are also being adopted in the smaller schools whose teachers have had an opportunity of becoming conversant with the advantages to be derived from their use.

For instance:

In New York City we find Weston instruments in service in
Stuyvesant High School
Wadleigh High School
DeWitt Clinton High School

In the Borough of Brooklyn, in
Erasmus High School
Commercial High School
Manual Training School, and
Girls' High School **Just ordered 40 Instruments**

In Jersey City they are in use in
Wm. L. Dickinson High School

In Plainfield, N. J., in
Plainfield High School

In East Orange, N. J., in
East Orange High School

In Philadelphia, in
Central High School

In Washington, in
McKinley High School
Manual Training Schools

In Buffalo, in,
Masten Park High School

(A letter addressed to the science teacher of any of the above schools will undoubtedly enable any teacher to obtain full information regarding the kind of service to be obtained from the use of Weston instruments.)

These few schools are merely indicative of the character of school in which Weston instruments are used, but a more significant fact is that practically every college or university in the United States adopts and uses them in preference to any other type marketed.

Use by the United States Government. Weston apparatus is used by the United States Government throughout its various branches, such as the army, navy, Isthmian Canal Zone, standardization laboratories, training schools, etc. It is manifestly impossible to make any definite statement as to the proportion Weston instruments bear to the total number of indicating electrical measuring instruments used by the Government, but we believe it to be a conservative statement that at least two-thirds of the direct-current instruments are of Weston manufacture, the remainder comprising, of course, instruments of substantially all other makes.

Likewise, Weston instruments, or imitations thereof, will be found to preponderate in practically all certification laboratories throughout the civilized world.

Weston Instruments in Use in New York City. In New York City 85 per cent of the isolated plants in office buildings, hotels, etc., are equipped with Weston switchboard and portable instruments.

The foregoing facts are presented merely to explain to what extent the student, as a practical man, will encounter Weston instruments in after life.

A SUGGESTION

How the Teacher can Convince Himself. We are convinced that, if any teacher will ask any typical electrical engineer to advise him the make or type of instrument that is standard, Weston instruments will be recommended; and we are equally convinced that if any teacher who is earnest in his endeavor to improve his course and equipment will carefully note the character of instrument the school supply dealers generally advocate, and will then spend one or two hours visiting electric plants, laboratories or manufacturing establishments using electrical power in his neighborhood, he will agree that it requires a most fertile imagination to find any similarity between those dealers' instruments and the ones found and used in the commercial establishments to which we refer.

A trip of such a character will be more convincing than volumes of arguments we might set forth.

REASONS WHY INFERIOR INSTRUMENTS HAVE BEEN IN USE

We have stated there is no sound reason why instruments similar to those met with in after life should not be used in the schools, despite the fact that it is easy to understand why inferior contrivances have obtained so strong a foothold.

The Attitude of the School-supply Dealer. Most school-supply dealers have for years assumed that almost any kind of electrical measuring instruments would be acceptable to, or tolerated in school laboratories, and hence have manufactured or marketed the abortive measuring contrivances to which we particularly refer. Because they required no ingenuity to devise, and cost little to make, they could be sold at a lower price than really serviceable instruments and still assure the purveyors a handsome profit.

However, there are at least two dealers who have pursued the contrary course and who have been primarily interested in selling apparatus of real merit to science teachers. In justice to these exceptions we should like to mention their names, but unfortunately cannot do so without risk of having our motive misinterpreted.

To a certain extent the responsibility for the continued sale of unsatisfactory instruments has been due to illustrations and descriptions which have appeared in text books, because the fact that such inferior contrivances have been given this unwarranted consideration has naturally led dealers to conclude that a demand for them existed, and also misled science teachers into assuming that they had merit.

The Last Stand of the Dealers' Instrument. It is a fact that there has been practically NO OTHER OUTLET for these wretched indicating contrivances than through the SCHOOLS, and were it not for conditions we have referred to, such makeshift instruments would long since have disappeared from that market.

Cost. The lure of the slightly lower original cost of an instrument is undoubtedly a great inducement to a teacher, because it allows him to spread his limited appropriation over more equipment; and is an inducement to a Board of Education purchasing department, because it examines prices and is apt to be primarily governed by price, unless the teacher makes specific recommendations.

Quality Preferable to Quantity. It is better, however, to have quality at a slight sacrifice of quantity in laboratory equipment, and it is also much cheaper to have quality, especially when considering electrical measuring instruments.

The fallacy of the idea that the inferior apparatus is more economical is best understood by considering the life of a poor and a good instrument and thus obtaining a knowledge of the cost of each per year of service.

Objections to the Tangent Galvanometer. In such a comparison the suspension type of tangent galvanometer can be briefly dispensed with, because the objections to it are numerous for High School use. It is extremely easy to injure; it consumes much time in reading that can be devoted to other purposes; it is difficult to read closely; it requires adjustment of the plane of its coil in the magnetic meridian; it is sensitive to stray magnetic fields and has a multiplicity of binding posts; *and the probabilities are that the average man will never be called upon to use anything like it after graduation.*

In fact, high-grade voltmeters and ammeters are decidedly preferable to tangent galvanometers for every purpose for which the latter instruments are used in High School laboratories. They have none of the objectionable features of galvanometers, and will, moreover, be of the greatest service for many tests and purposes to which the galvanometer is in no wise adapted.

Instruments of Quality are not High-priced. Standard Weston Voltmeters may be bought from about $10.50 upwards, depending upon the size and range, and upon whether switchboard or portable models are required, and these voltmeters are identical with those used in every-day practical commercial work. (See the article on p. 772 of " School Science and Mathematics " for December, 1912, written by C. L. Vestal of Carl Schurz High School, Chicago.)

FOOL-PROOF INSTRUMENTS

Due perhaps to arguments advanced by some makers in behalf of certain types of instruments they specifically recommend for school purposes, many teachers will be inclined to ask whether a high-grade instrument is fool-proof.

" Fool-proof " is a rather misleading term, and the question is naturally invoked : " Is any instrument 'fool-proof'? " The term " fool-proof," as applied to the instruments to which we have reference, is a cloak designed to cover a multitude of imperfections, chief among which are ill-designed, cumbersome parts that give rise to an unwarranted semblance of strength. The fallacy of asserting that heavy parts necessarily imply strength and durability is the usual refuge of the ignorant and the unskilled.

But is any apparatus fully "fool-proof"? Is any of the paraphernalia of the chemical laboratory proof against unreasonable or unintelligent use? Is it not necessary to give instruction regarding the proper use of such apparatus and then insist that instructions be observed?

Are watches, thermometers, chemical balances, or are any mechanical or electrical contrivances non-destructible when subjected to unreasonable use?

Is "fool-proof" really a fair term to apply to an electrical measuring instrument, or to any other appliance or material placed in the hands of students?

Is it not preferable to proceed on the basis that we are dealing with sound, healthy young minds of average intelligence, and then bend every effort to stimulate that intelligence and foster its expansion? Should we not carefully explain to the students the reason for making certain connections to an electrical measuring instrument and thus instill in their minds the necessity of exercising care in all their experiments, in order to promote self-reliance, and as we cultivate intelligent thought and sound reasoning, do we not pave the way to higher education?

If we give pupils apparatus that may be grossly abused without being damaged, we invariably do so at the sacrifice of certain good qualities that the apparatus should possess, and moreover, we encourage laxity and carelessness—characteristics which are extremely detrimental in school and in after life.

To answer then the question: "Is a high-grade instrument 'fool-proof'?"—we must reply, "Not wholly"; but we do lay particular stress on the fact that all Weston instruments are so designed that they will withstand overloads of several hundred per cent of the quantity represented by their full scale indications, and upon the fact that this extremely reasonable factor of safety is imparted without sacrificing any of the qualities which render the instruments thoroughly accurate, reliable and durable.

It, therefore, follows that if any Weston instrument be inadvertently connected in a circuit of unknown value, a very exceptional safeguard is afforded the user against damage to his property.

Moreover, if ordinary instructions be given to the students relating to wiring diagrams and with respect to explaining the functions of instruments, the only probability of damage is that due to human fallibility, because every multiple range Weston instrument has each binding post distinctly marked to indicate the upper value of the range or scale to which it affords a means of connection.

If teachers desire the benefit of our experience in order to assist them in giving proper instructions to students, we shall be glad to extend our best support upon request.

The other day a science teacher, who has insisted upon the use of high-grade instruments in his laboratory, told us that he freely placed these instruments at the disposal of his first-year students and had yet to experience any damage to any instrument, despite the fact that he had merely given them ordinary instructions with regard to their use and the connections to be made—in fact, the same instructions as he would have given had he been dealing with inferior instruments.

THE TEACHER IS DEPENDENT UPON MANUFACTURERS' REPRESENTATIONS

Because it is true that teachers and departmental purchasing agents are to a great extent at the mercy of the instrument manufacturer, in the sense that they are compelled to base their judgment upon statements or claims made by representatives, or catalogues sent out by manufacturers, it is pertinent to say a few words about indicating electrical measuring instruments in general.

As we have intimated, one of the greatest safeguards to the teachers is the reliability and responsibility of the manufacturer.

The Value of a Reputation. A concern which has conscientiously conducted a business for over a score of years, and which, during that time, has built up a world-wide reputation for the highest quality of product and for fair dealing in the sense of stinting neither time nor money to improve its product in every possible manner—and then standing back of that product—naturally inspires confidence, because under no circumstances would it consent to jeopardize that reputation by making statements that could not be thoroughly substantiated by facts.

Such a record is that which the Weston Electrical Instrument Company enjoys, and we refer to it merely to give force to the statement that is to follow, viz.: that substantially every type of indicating electrical measuring instrument to be found on the market to-day is either an imitation of an existing type of Weston instrument, or a development of a type that was devised by, or thoroughly and painstakingly analyzed by, this Company and discarded because unworthy of perpetuation when tested in the crucible of practical and commercial work.

Proper Development of an Instrument. The only honest or proper method of developing and manufacturing a thoroughly reliable type of electrical measuring instrument is to proceed strictly on the line of doing all the experimental work at the expense of the manufacturer and not at the expense of the user. In other words, to refrain from selling an instrument until it is known that it will fully meet the rigorous requirements imposed by actual practical service, and will therefore be so durable, generally serviceable, and accurate, that it will never be relegated to the scrap-heap.

To assure these qualities it is absolutely imperative to spend large sums of money in order to conduct most elaborate experiments with the object of properly solving all the many and complex problems encountered in the development of the best possible form of the instrument under consideration. After it becomes certain that no further advance can be made in the betterment of the type or form, it then becomes necessary to devise the best manufacturing methods for the production of the composite parts in such manner that they will be absolutely interchangeable, and so ensure perfect uniformity of product and prompt and economical repairing if abused.

Interchangeable Parts. All parts of Weston instruments are made strictly to gauge and are made by special tools, jigs, fixtures, etc., all of which call for a tremendous investment before a type is marketed; but as previously stated, unless such a policy is rigidly adhered to, it is impossible thoroughly to safeguard the buyer.

The Guise under which a Poor Instrument is Offered. It is comparatively easy for any manufacturer to make a type of indicating electrical measuring instrument that will initially conform with reasonable accuracy to certain simple tests. In fact, a manufacturer would be foolish to attempt to market a type which would not, under superficial examination, appear to be fairly accurate. However, the determining qualification of an electrical instrument is its ability to retain its accuracy day in and day out when subjected to ordinary use and abuse and still be of a type that is flexible in its application and hence highly serviceable.

(As an illustration of what we mean by continued service, we submit that Mr. Randall of Pratt Institute informs us that there are certain Weston instruments in the Institute laboratories that have been in daily use for over ten years and are still rendering the same efficient service as when originally procured. Much more impressive illustrations could be cited.)

Movable Coil Types of Instruments. Many types of instruments, including Weston, have pivoted movable elements.

Such instruments may have many vital component parts, each of which should be most conscientiously designed and prepared. There are, for instance, magnets, springs, steel pivots, jewels, resistor wires, etc.

An Instrument, Like a Chain, is no Stronger than its Weakest Link. Unless these parts are designed and constructed in a most painstaking manner, each is subject to variation. Magnets may not be properly hardened or treated, or may be given such air clearances as to subject them to change in strength. Springs may not be properly tempered or of proper material to allow them to remain constant. Pivots may be too soft or have too large an area of contact. Jewels may be of poor quality (in many cheap instruments agate is substituted for jewels) and may be rough, pitted or cracked. Resistor wires, unless properly aged, are prone to change with time, and, if not made of special alloys, have serious changes in value with changes of temperature.

Light Weight on the Pivots and Jewels. But aside from these pitfalls encountered in mediocre instruments, any of which may mean loss of service or at least undependable service, no electrical measuring instrument may be made accurate, serviceable and durable unless its movable element is designed so as to have the lowest possible weight consistent with a sufficient strength and an abundant factor of safety to continually perform its functions under all the trying conditions of practical use.*

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*See letter from Mr. H. W. Price, of Toronto University, which is reproduced near the end of this monograph.

In other words really meritorious instruments must be built with infinite care, and their production is fully as exacting as watch-making of the highest grade.

Friction. Friction, the tendency of the pointer to stick at certain parts of the scale, is generally due to wear and tear on pivots or jewels, or to dirt which may enter the instrument. The wear and tear on pivots and jewels is prodigiously in excess of any direct comparison of the weights of any two movable elements, and is enormously increased if a movable coil is not properly damped (made dead beat). Therefore, a movable coil which oscillates excessively before coming to rest, imposes detrimental wear on the pivots and jewels.

(The various essentials of a high-grade instrument are so numerous that they require a much more complete exposition than can be given in this monograph, which is intended merely as a foreword to teachers advising that we are anxious to be of service to them.)

To proceed, then, we confine ourselves to the statement that the types of instruments that have been most commonly used in the High Schools are in reality poor toys, designed without regard for accuracy, without regard for durability, and without regard for utility. In a word, they give rise to misinformation and trouble.

Investigation Worth While. If teachers will investigate the mechanical and electrical contrasts between these poor instruments and the highest grade instruments, and will familiarize themselves with the exceedingly slight difference in original purchase price, they will soon perceive that loss of service, cost of maintenance and renewals of inferior instruments run up their cost so rapidly as to make them vastly more expensive to use than a high-grade instrument built for continued service.

As a final word on this subject we give one more quotation from a well-known science teacher:

" A very serious objection to the use of the types of instruments that have been most commonly used in our laboratories is the difficulty experienced in getting the same reading upon repetition of the same test.

" This naturally creates doubt in the mind of the pupil concerning the stability of an instrument which also entails loss of time, and the only method of overcoming this objection is to buy reliable instruments of high grade, because then this doubt is dispelled and a ready means of checking a test is available."

HOW TO ORDER INSTRUMENTS

The method that teachers have been compelled to adopt in most cases when ordering or requisitioning instruments has tended to thwart obtaining the type of instruments best suited for their requirements, and has therefore made it relatively easy for dealers to continue to supply grades of measuring devices wholly unsuited for school purposes.

The usual procedure in purchasing has been for the teacher to place his requisition upon the purchasing department of a Board of Education, which in turn advertises or sends out proposals for bids on the apparatus.

Special Effort Necessary if High-grade Instruments are Desired. Under such circumstances, unless special effort is made, it is difficult to obtain what is desired, because the board usually cannot (if we are correctly informed) specify any one special make of apparatus to the exclusion of other makes, providing other makes are of equal grade.

In other words, if the teacher has failed to impress upon the board that he desires a Weston instrument, or one of equal quality, the board would probably merely ask for a quotation on an ammeter or voltmeter of some specific range, and it would then be very unlikely to receive bids on any other types of instruments except those which were of the greatest advantage to the dealers to sell.

This condition of affairs has done more to encourage the sale of inferior instruments to the schools than any other, but it has been strongly augmented because in many cases teachers had not appreciated the importance of studying the differences in instruments, and probably assumed that the board was providing them with a satisfactory type.

It is relatively simple to obtain instruments that are the same in appearance, construction, accuracy and durability as those used in practical commercial work.

All that is necessary is for a teacher to become convinced of the advantage to himself and his pupils in securing dependable instruments and then to make a slight additional effort when placing his order by carefully specifying what he wants and rejecting anything that fails to come up to the requirements.

How to Specify. Suppose a teacher wants a Weston portable voltmeter of three ranges of 150, 15 and 3 volts. He will then request the Board of Education to obtain for him:

> " One Weston voltmeter, model 45, described on p. 21 of Weston Bulletin No. 501. Ranges 150–15 and 3 volts.
>
> " A Weston instrument is specially preferred, and no other type will be considered or accepted unless it can be conclusively proven, instead of merely alleged, that it is equal in all respects to the Weston."

We will cheerfully place catalogs at the disposal of any teacher, and if our literature is not already on file in every Board of Education, it will be sent immediately upon request.

Have a Weston Catalog Available. When you desire an instrument, always send for or consult a Weston Catalog, Bulletin, or Monograph instead of looking for instruments in the ordinary school-supply dealers' catalog, but after you have received the Weston catalog, it will prove of great interest to compare the Weston and dealers' types and prices.

AFTERTHOUGHTS

While all teachers who have had experience in the use of Weston instruments will heartily testify to their exceptional quality, there still prevails among many teachers the impression that they are too good for general student service, even though it is stated that they are imperatively needed in the High School laboratory for testing other instruments or apparatus.

In reply to this contention we repeat that Weston instruments may be now purchased which range in list price from $10.50 upward, depending on the type and scales selected;

That they are accurate, exceptionally durable and generally serviceable;

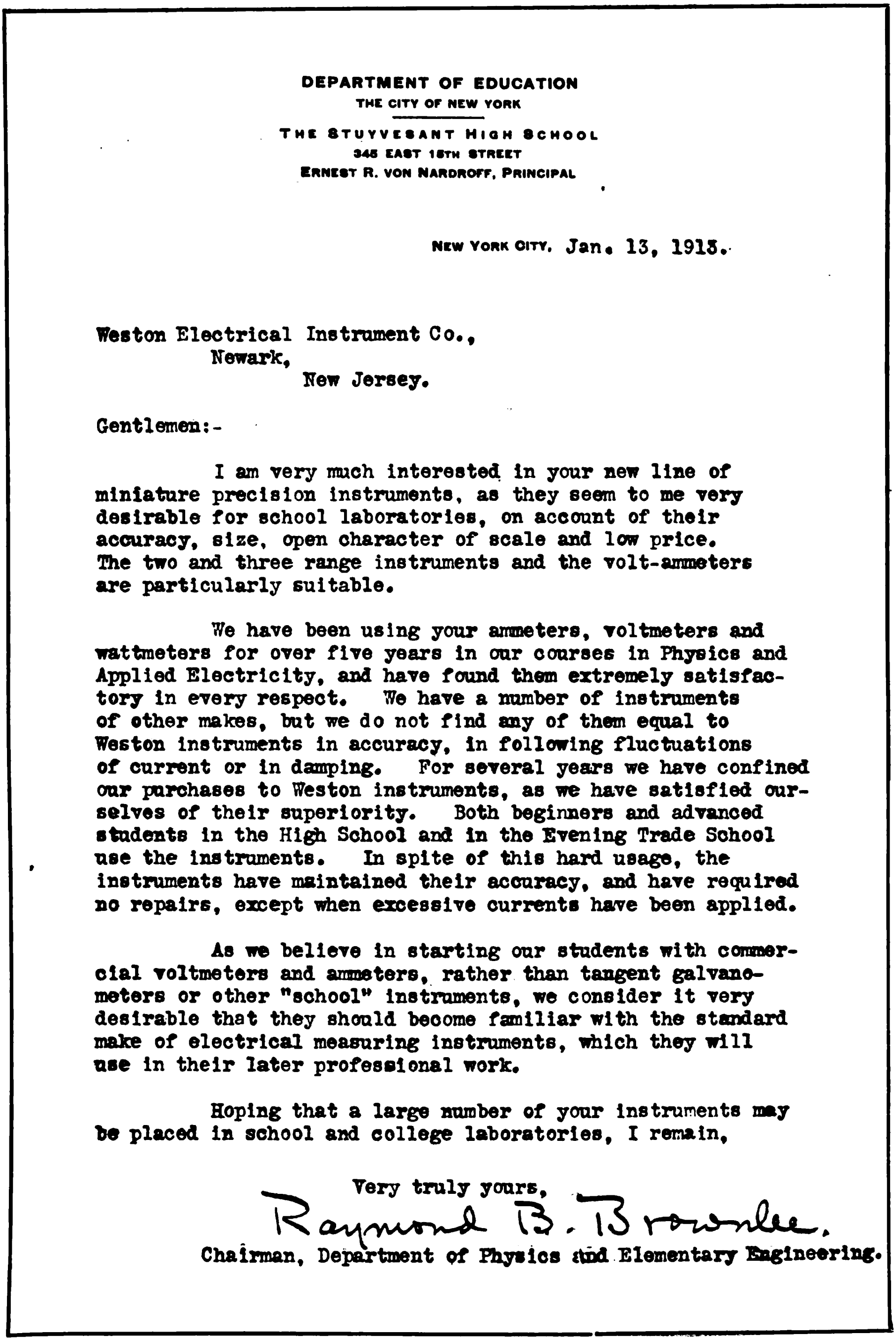
That they are as easy to understand and use as other instruments;

That they are identical with instruments that will be used by the majority of students after graduation;

That they impart a knowledge of the true value of electrical measurement; *and*

That they are infinitely better for all laboratory purposes than instruments of any other manufacture.

If these facts are carefully considered and investigated, we are certain that the impression referred to will be dispelled, and that the marked advantage of using high-grade instruments for every student purpose will become more universally appreciated.



DEPARTMENT OF EDUCATION
THE CITY OF NEW YORK
THE STUYVESANT HIGH SCHOOL
345 EAST 15TH STREET
ERNEST R. VON NARDROFF, PRINCIPAL

NEW YORK CITY. Jan. 13, 1915.

Weston Electrical Instrument Co.,
Newark,
New Jersey.

Gentlemen:-

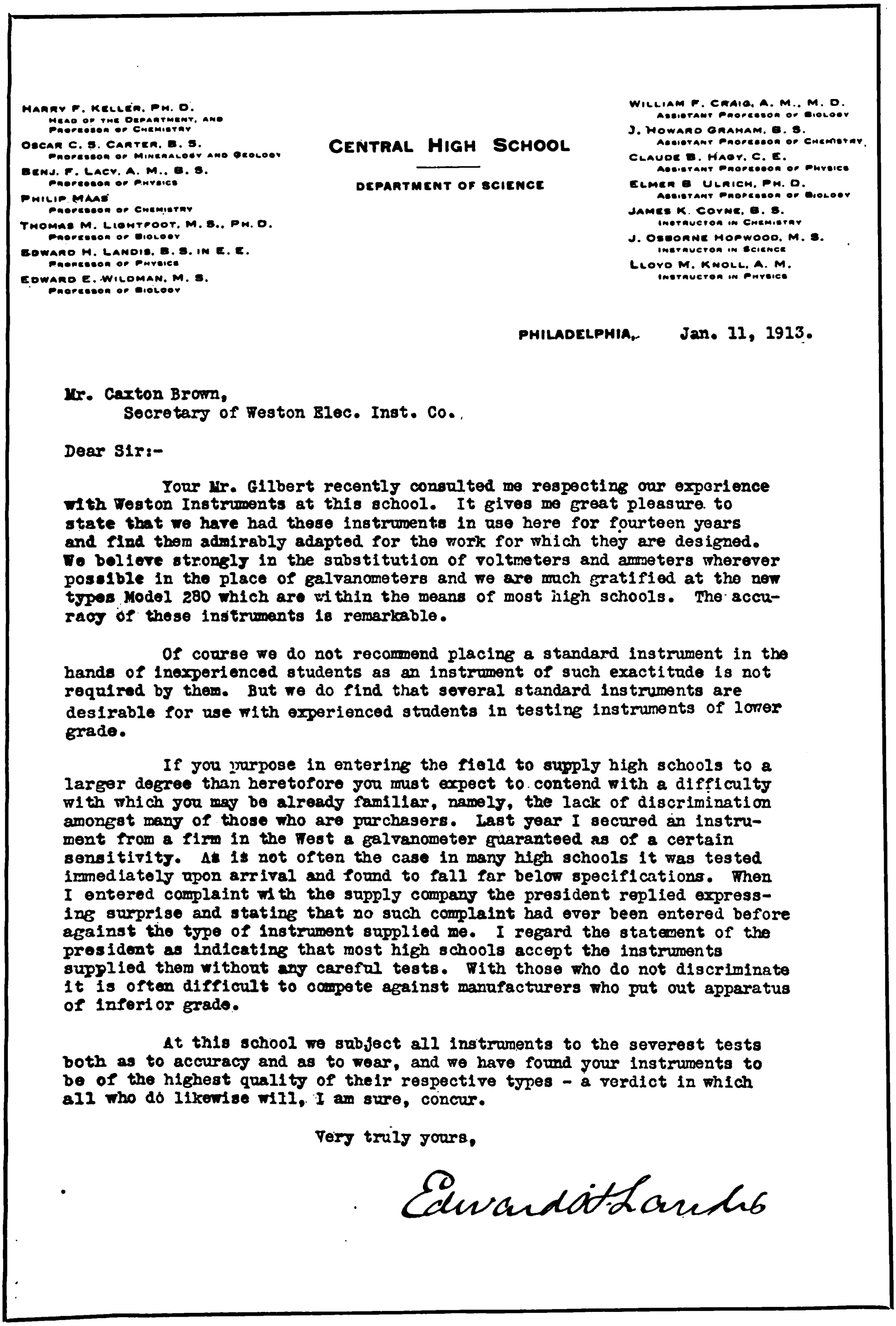
I am very much interested in your new line of miniature precision instruments, as they seem to me very desirable for school laboratories, on account of their accuracy, size, open character of scale and low price. The two and three range instruments and the volt-ammeters are particularly suitable.

We have been using your ammeters, voltmeters and wattmeters for over five years in our courses in Physics and Applied Electricity, and have found them extremely satisfactory in every respect. We have a number of instruments of other makes, but we do not find any of them equal to Weston instruments in accuracy, in following fluctuations of current or in damping. For several years we have confined our purchases to Weston instruments, as we have satisfied ourselves of their superiority. Both beginners and advanced students in the High School and in the Evening Trade School use the instruments. In spite of this hard usage, the instruments have maintained their accuracy, and have required no repairs, except when excessive currents have been applied.

As we believe in starting our students with commercial voltmeters and ammeters, rather than tangent galvanometers or other "school" instruments, we consider it very desirable that they should become familiar with the standard make of electrical measuring instruments, which they will use in their later professional work.

Hoping that a large number of your instruments may be placed in school and college laboratories, I remain,

Very truly yours,
Raymond B. Brownlee.
Chairman, Department of Physics and Elementary Engineering.



Harry F. Keller, Ph. D.
Head of the Department, and
Professor of Chemistry
Oscar C. S. Carter, B. S.
Professor of Mineralogy and Geology
Benj. F. Lacy, A. M., B. S.
Professor of Physics
Philip Maas
Professor of Chemistry
Thomas M. Lightfoot, M. S., Ph. D.
Professor of Biology
Edward H. Landis, B. S. in E. E.
Professor of Physics
Edward E. Wildman, M. S.
Professor of Biology

CENTRAL HIGH SCHOOL

DEPARTMENT OF SCIENCE

William F. Craig, A. M., M. D.
Assistant Professor of Biology
J. Howard Graham, B. S.
Assistant Professor of Chemistry
Claude B. Hagy, C. E.
Assistant Professor of Physics
Elmer B Ulrich, Ph. D.
Assistant Professor of Biology
James K. Coyne, B. S.
Instructor in Chemistry
J. Osborne Hopwood, M. S.
Instructor in Science
Lloyd M. Knoll, A. M.
Instructor in Physics

PHILADELPHIA, Jan. 11, 1913.

Mr. Caxton Brown,
Secretary of Weston Elec. Inst. Co.,

Dear Sir:-

Your Mr. Gilbert recently consulted me respecting our experience with Weston Instruments at this school. It gives me great pleasure to state that we have had these instruments in use here for fourteen years and find them admirably adapted for the work for which they are designed. We believe strongly in the substitution of voltmeters and ammeters wherever possible in the place of galvanometers and we are much gratified at the new types Model 280 which are within the means of most high schools. The accuracy of these instruments is remarkable.

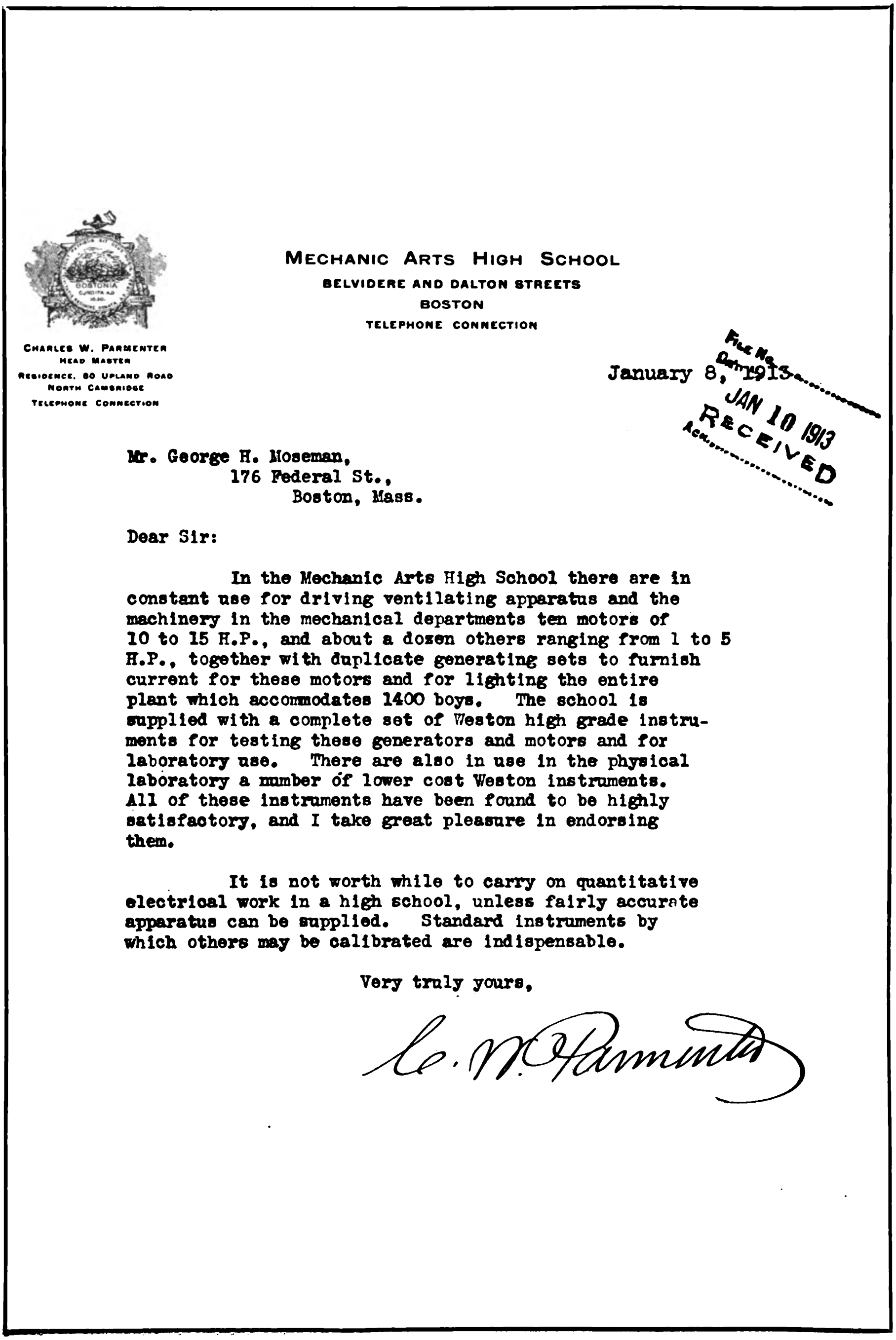
Of course we do not recommend placing a standard instrument in the hands of inexperienced students as an instrument of such exactitude is not required by them. But we do find that several standard instruments are desirable for use with experienced students in testing instruments of lower grade.

If you purpose in entering the field to supply high schools to a larger degree than heretofore you must expect to contend with a difficulty with which you may be already familiar, namely, the lack of discrimination amongst many of those who are purchasers. Last year I secured an instrument from a firm in the West a galvanometer guaranteed as of a certain sensitivity. As is not often the case in many high schools it was tested immediately upon arrival and found to fall far below specifications. When I entered complaint with the supply company the president replied expressing surprise and stating that no such complaint had ever been entered before against the type of instrument supplied me. I regard the statement of the president as indicating that most high schools accept the instruments supplied them without any careful tests. With those who do not discriminate it is often difficult to compete against manufacturers who put out apparatus of inferior grade.

At this school we subject all instruments to the severest tests both as to accuracy and as to wear, and we have found your instruments to be of the highest quality of their respective types - a verdict in which all who do likewise will, I am sure, concur.

Very truly yours,

Edward H Landis



MECHANIC ARTS HIGH SCHOOL
BELVIDERE AND DALTON STREETS
BOSTON
TELEPHONE CONNECTION

CHARLES W. PARMENTER
HEAD MASTER
RESIDENCE, 80 UPLAND ROAD
NORTH CAMBRIDGE
TELEPHONE CONNECTION

January 8, 1913.

File No.
Corr.
JAN 10 1913
RECEIVED
Ack.

Mr. George H. Moseman,
176 Federal St.,
Boston, Mass.

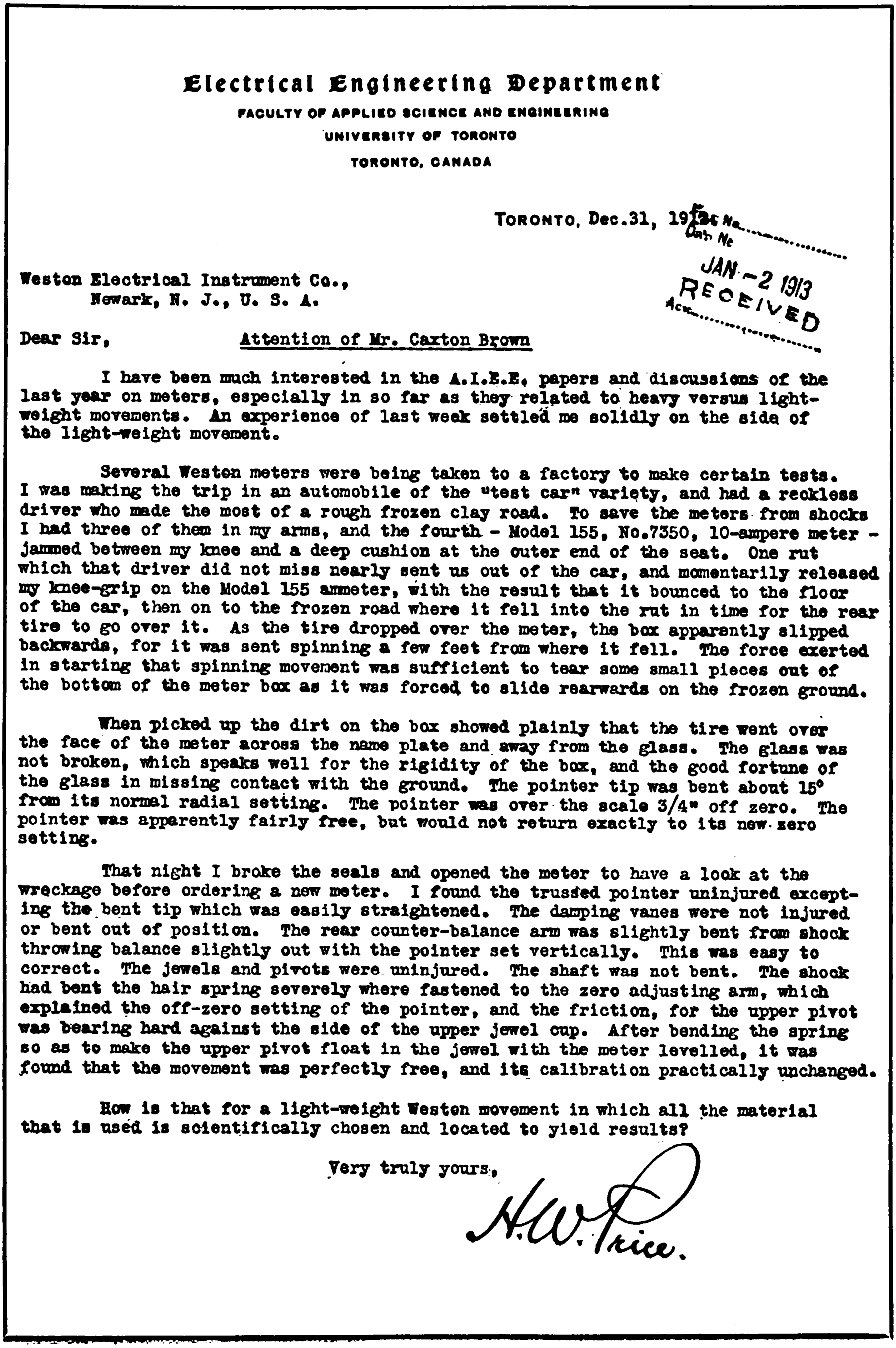
Dear Sir:

In the Mechanic Arts High School there are in constant use for driving ventilating apparatus and the machinery in the mechanical departments ten motors of 10 to 15 H.P., and about a dozen others ranging from 1 to 5 H.P., together with duplicate generating sets to furnish current for these motors and for lighting the entire plant which accommodates 1400 boys. The school is supplied with a complete set of Weston high grade instruments for testing these generators and motors and for laboratory use. There are also in use in the physical laboratory a number of lower cost Weston instruments. All of these instruments have been found to be highly satisfactory, and I take great pleasure in endorsing them.

It is not worth while to carry on quantitative electrical work in a high school, unless fairly accurate apparatus can be supplied. Standard instruments by which others may be calibrated are indispensable.

Very truly yours,

C. W. Parmenter



Electrical Engineering Department
FACULTY OF APPLIED SCIENCE AND ENGINEERING
UNIVERSITY OF TORONTO
TORONTO, CANADA

TORONTO, Dec.31, 1912

JAN -2 1913
RECEIVED

Weston Electrical Instrument Co.,
Newark, N. J., U. S. A.

Dear Sir, Attention of Mr. Caxton Brown

I have been much interested in the A.I.E.E. papers and discussions of the last year on meters, especially in so far as they related to heavy versus light-weight movements. An experience of last week settled me solidly on the side of the light-weight movement.

Several Weston meters were being taken to a factory to make certain tests. I was making the trip in an automobile of the "test car" variety, and had a reckless driver who made the most of a rough frozen clay road. To save the meters from shocks I had three of them in my arms, and the fourth - Model 155, No.7350, 10-ampere meter - jammed between my knee and a deep cushion at the outer end of the seat. One rut which that driver did not miss nearly sent us out of the car, and momentarily released my knee-grip on the Model 155 ammeter, with the result that it bounced to the floor of the car, then on to the frozen road where it fell into the rut in time for the rear tire to go over it. As the tire dropped over the meter, the box apparently slipped backwards, for it was sent spinning a few feet from where it fell. The force exerted in starting that spinning movement was sufficient to tear some small pieces out of the bottom of the meter box as it was forced to slide rearwards on the frozen ground.

When picked up the dirt on the box showed plainly that the tire went over the face of the meter across the name plate and away from the glass. The glass was not broken, which speaks well for the rigidity of the box, and the good fortune of the glass in missing contact with the ground. The pointer tip was bent about 15° from its normal radial setting. The pointer was over the scale 3/4" off zero. The pointer was apparently fairly free, but would not return exactly to its new zero setting.

That night I broke the seals and opened the meter to have a look at the wreckage before ordering a new meter. I found the trussed pointer uninjured excepting the bent tip which was easily straightened. The damping vanes were not injured or bent out of position. The rear counter-balance arm was slightly bent from shock throwing balance slightly out with the pointer set vertically. This was easy to correct. The jewels and pivots were uninjured. The shaft was not bent. The shock had bent the hair spring severely where fastened to the zero adjusting arm, which explained the off-zero setting of the pointer, and the friction, for the upper pivot was bearing hard against the side of the upper jewel cup. After bending the spring so as to make the upper pivot float in the jewel with the meter levelled, it was found that the movement was perfectly free, and its calibration practically unchanged.

How is that for a light-weight Weston movement in which all the material that is used is scientifically chosen and located to yield results?

Very truly yours,

H. W. Price.

January 8, 1913.

The Weston Electrical Instrument Co.,
Waverly Park, U. S.

Dear Sirs:

We have had in use a portable milammeter and a voltmeter of your make during the past 17 years. We also have four Eclipse switchboard instruments which were purchased about three years ago.

We have used these instruments for class work in Physics, as well as in Advanced Electricity, and find them reliable and altogether satisfactory. They serve us as standards for testing our other instruments and apparatus.

Yours very truly,
J. Y. PARCE,
Instructor in Machine Work and Electricity,
Denver Manual Training High School.

January 7, 1913.

Mr. F. E. Gilbert,
Philadelphia, Pa.

Dear Sir:

Yours of the 4th instant received. I am a member of the committee you mention.

In the Physics Department of the High and Normal Training Schools (seven in all) in Washington City we have over forty (40) Weston Electrical Measuring Instuments. The number of different students using them exceeded seven hundred (700) students. These students were enrolled in every year of our four (4) years' course. I think Weston Instruments were first used by us about four (4) years ago. None of them have been seriously injured. Needles have been bent and other minor injuries have been done to the instruments. (As a matter of experience I never allow an external shunt instrument to be used by a beginner.) I am well satisfied with my experiment in placing them in the hands of students.

Send us any advertisements you get out, especially of the almanac or calendar type.

Yours truly,
WM. A. HEDRICK,
Head of the Dept. of Physics.